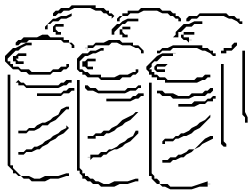
MAKING CARBONIC ACID

Objectives:

Students will investigate the concepts of pH, acidity, and alkalinity, demonstrate how carbonic acid is formed, and describe how carbonic acid can dissolve limestone to create caves.

Materials:

- White litmus paper
- Small cups, one per student
- Straws, one per student (coffee stirrers will work)
- Soda water or soda pop, preferably clear
- Flat soda water or soda pop
- Vinegar
- Distilled water
- Baking soda



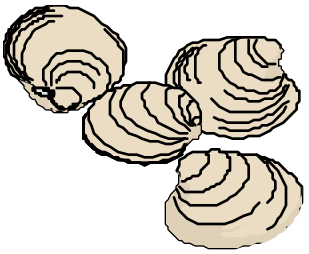
Procedure:

1. Ask the students, "What is an acid?" Discuss the concept of acidity. What acids are the students familiar with? Discuss citric acid, stomach acids, battery acids, etc. Discuss what makes acids acidic (many hydrogen ions in solution). What are characteristics of most acids?
2. What are bases? Discuss alkalinity. What makes bases basic? (Many hydroxides in solution.) Draw the pH scale on the board, from 0 to 14. Refer to the attached chart to associate pH values with hydrogen ions with familiar household substances. This should help the students get better control of the concepts. Discuss the meaning of the numbers in the scale. (1×10^{-7} hydrogen ions in solution = pH 7, where the parts of H+ are 0.0000001 and for a pH of 2 the parts of H+ are 0.01 making it more acidic, etc.) The lower the pH, the higher the acidity. 7 is neutral. (Acid is low, base is high, just like a before b in the alphabet.) Decide what information your students would benefit the most from. Younger students do not need to be introduced to the ions in solution information, etc.
3. Give each student a small cup of vinegar, a small cup of distilled water, a small cup of baking soda/water solution, and 3 pieces of white litmus paper. The litmus paper will turn red in an acid, blue in a base, and remain white in a neutral solution.
4. Have the students dip a piece of litmus paper in each cup and quickly remove it. The color change should be instantaneous.
5. Next, discuss how water can become acidic. What chemical transformation needs to take place? (The hydrogens need to dissociate from the oxygen.) What happens when water mixes with carbon dioxide? Write the equation on the board

   $H_2O + CO_2 \rightarrow H_2CO_3$ (carbonic acid)

   The hydrogens are now bonded to carbon instead of oxygen.
6. Give each student a straw or coffee stirrer and another piece of litmus paper. Have them blow bubbles into their cup of distilled water for approximately one minute, then test

WHAT IS LIMESTONE?



Objective:

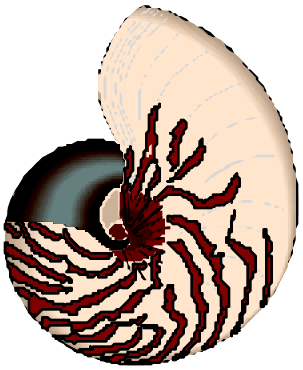
Students will investigate how limestone forms.

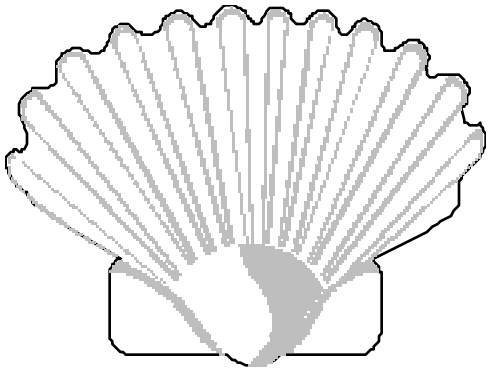
Materials:

- Several seashells (some whole, some broken, some crushed)
- Piece of limestone with an imbedded brachiopod fossil

Procedure:

1. Ask students, "What is limestone?" What type of rock is limestone? Review the three different rock types. (Igneous, metamorphic, and sedimentary.) How are sedimentary rocks formed? (Deposited in a body of water.)
2. Ask the students if they have ever collected seashells on a beach. Where do the shells come from? (Animals in the water.) What are these shells made of? (Calcium carbonate.) Discuss the seas that once covered many parts of the United States. Shelled animals also lived in these ancient seas. Show the students several examples of shells, and pass them around.
3. Have the students ever found broken seashells? What might cause them to break? Discuss the force of waves in the ocean. Show the students several examples of broken shells. Some are crushed into a fine powder! What will happen to the shells or shell pieces over time? Where will they go? (They settle to the ocean floor.)
4. Over a long period of time (thousands or millions of years) the shells and shell pieces at the bottom of the ocean will pile up into thick layers. Some of these layers can be thousands of feet thick!
5. How would it feel to be a shell at the bottom of the pile? How heavy would the shells above you be? Discuss how pressure from the weight of the shells causes the shells to cement together over time. The resulting rock is limestone, composed of calcium carbonate.
6. Show the students the piece of limestone. What do they see imbedded in the rock? Brachiopod fossils are found in limestone wherever the shells were not completely broken.
7. What might cause an ocean to recede? Discuss freezing, (and water being contained in glaciers) changes in topography, (such as uplift), filling with sediments and evaporation. What will be left behind when the ocean dries up or moves? A bed of limestone!





Deep 31 Cukurpinar Dudeni: Anamur, Turkey 1195m

Deep 32 Complesso del Monte Corchia: Toscana, Italy 1190m

Deep 33 Vandima: Rombanaki, Slovenia 1182m

Deep 34 Sistema Aranonera: Huesca, Spain 1179m

Deep 35 Jubilaumsschacht: Salzburg, Austria 1173m

Deep 36 g.de Bracas de Thurugne 6: Pyre., France 1172m

Deep 37 Abisso Vive le Donne: Lombardia, Italy 1170m

Deep 38 Anou Ifflis: Bouira, Algeria 1170m

Deep 39 Sima 56 de Andara: Cantabria, Spain 1169m

Deep 40 Torca Idoubeda: Picos do Europa, Spain 1167m

Deep 41 Sistema Badlaona: Huesca, Spain 1150m

Deep 42 Tanne des Pra d'Zeures: Haute-Savoie, France 1148m

Deep 43 Sistema del Xitu: Asturias, Spain 1135m

Deep 44 Sistem Molika Pec: DleskovskaPlanto, Slovenia 1130m

Deep 45 Neide – Muruk Cave: New Britain, Papua New Guinea 1123m

Deep 46 Arabikskaja: Abkhazia, Georgia 1110m

Deep 47 Kazumura Cave: Hawaii, USA 1101m

Deep 48 Schneeloch: Salzburg, Austria 1101m

Deep 49 Sima G.E.S.M. de los Hoyos del Pilar: Malaga, Spain 1101m

Deep 50 Jagergrunntro-Hohlensystem: Salzburg, Austria 1078mChina).

Deep 11 Sistema Cheve: Oaxaca, Mexico 1386m

Deep 12 Evern GUNAY sinkhole: Cukurpinar, Turkey 1377m

Deep 13 Sniezhnaja-Mezhonnogo: Abkhazia, Georgia 1370m

Deep 14 Ceki 2: Rombonski Podi, Slovenia 1370m

Deep 15 Reseau de la Pierre Saint Martin: Pyre., France 1342m

Deep 16 Siebenhengste-hohgant Hohlensystem: Bern, Switzerland 1340m

Deep 17 Slovacka jama: Velebit, Croatia 1295m

Deep 18 Cosanostraloch – Berger- Platteneck Hohle: Austria 1291m

Deep 19 Gouffre Berger-Bouffre do la Fromagere: Isere, France 1278m

Deep 20 Pozo del Madejuno: Leon, Spain 1255m

Deep 21 Torca dos los Rebecos: Asturias, Spain 1255m

Deep 22 Abisso Paolo Roversi: Toscana, Italy 1249m

Deep 23 Vladimir V. Iljukhina System: Alkhazia, Georgia 1240m

Deep 24 Sotano Akematl: Puebla, Mexico 1226m

Deep 25 Schwerhohlensystem (Batmanhole): Salzburg, Austria 1219m

Deep 26 Abisso Ulivifer: Toscana, Italy 1215m

Deep 27 Kihaje Xontjoa: Oaxaca, Mexico 1209m

Deep 28 Gorgothakas: Crete, Greece 1208m

Deep 29 Dachstein-Mammuthohle: Oberosterreich, Austria 1199m

Deep 30 Crnelsko brezno: Rombonaki Podi, Slovenia 1198m

Long 41 Santo Tomas: Pinar del Rio, Cuba 46000m

Long 42 Crevice Cave: Missouri, USA 45546m

Long 43 Barenschacht: Bern, Switzerland 45400m

Long 44 sima del Hayal di Ponata: Vizeaya-Ayah, Spain 45000m

Long 45 Cumberland Caverns: Tennessee, USA 44444m

Long 46 Lamprechtsofen-Vogelschact: Salzburg, Austria 44000m

Long 47 Kolkbluser-Monsterhohle: Salzburg, Austria 43857m

Long 48 Sima del Mortero do Astrana: Cantabria, Spain 43000m

Long 49 Bol'shaja Oreshnaja: Russia, Russia 43000m

Long 50 Sistema de los Cuatro V.: Cantabria, Spain 43216m

Deep 1 Lamprechtosofen-Vogelshacht: Salzburg, Austria 1632m

Deep 2 gouffre Mirolda/ Lucien Coudlier: Haute-Savoie, France 1610m

Deep 3 Reseau Jean Bernard: Haute-Savoie, France 1602m

Deep 4 Torca del Cerro: Asturias, Spain 1589m

Deep 5 Shakta Vjacheslav Pantjukhina: Abkhazia, Georgia 1508m

Deep 6 Sistema Huautla: Oaxaca, Mexico 1475m

Deep 7 Sistema del Trave: Asturias, Spain 1441m

Deep 8 Boj-Bulok: Uzbekistan, Uzbekistan 1415m

Deep 9 Laminako Aterneko Leizea: Nararra, Spain 1408m

Deep 10 Sustavd Lukina jama: Velebit, Croatia 1393m

Long 21 Organ Cave System: West Virginia, USA 63569m

Long 22 Ogof Draenen: South Wales, UK 62000m

Long 23 Kazumura Cave, Hawaii, USA 61420m

Long 24 Nohoch Nah Chichn: Quintana Roo, Mexico 60985L

Long 25 Reseau de L'Alpe: Isere, France 60247m

Long 26 Red Del Rio Silencio: Cantabria, Spain 60000m

Long 27 Bullita Cave System: Northern Territory, Australia 57500m

Long 28 Kap-Kutan: Turkistan, Turkmenistan 57000m

Long 29 Sistema Huautla: Oazaca, Mexico 55953m

Long 30 Cenote Dos Ojos: Quintana Roo, Mexico 55322m

Long 31 reseau de la Dent de Crolles: Isere, France 55250m

Long 32 Mamo Kananda: Southern Highland, Papua New Guinea 54800m

Long 33 reseau de la Pierre Saint Martin: Pyre., France 53950m

Long 34 Blue Spring Cave, Tennessee, USA 53366m

Long 35 Dachstein-Mammuthohle: Oberosterreich, Austria 52944m

Long 36 Complesso del Monte Corchia: Toscana, Italy 52300m

Long 37 Martin Ridge System: Kentucky, USA 51884m

Long 38 Ogof Ffynnon Ddu: South Wales, UK 50000m

Long 39 Carlsbad Cavern: New Mexico, USA 49680m

Long 40 Gr. Cacerna de Palmarito: Pinar del Rio, Cuba 48000m

Long 1 Mammoth Cave: Kentucky, USA 517317m

Long 2 Optimisticeskaja:Ukrainskaja Ukraine 212000m

Long 3 Jewel Cave: South Dakota, USA 195615 m

Long 4 Holloch: Schwyz, Switzerland 182540m

Long 5 Lechuguilla: New Mexico, USA 170269m

Long 6 Wind Cave: South Dakota, USA 151600m

Long 7 Siebenhengste-hohgant Hohlensystem: Berne, Switzerland 145000L

Long 8 Friar Ridge Cave System: Kentucky, USA 144841m

Long 9 Ozernaja: Ukrainskaja, Ukraine 117000m

Long 10 Gua Air jernih-Lubang Batau Padeng: Sarawak, Malaysia 109000L

Long 11 System de Ojo Guarena: Burgos, Spain 100000m

Long 12 reseau de la Coumo d'Hyouernedo: Naute-Garonne, France 94843L

Long 13 Sistema Purificacion: Tamaulipas, Mexico 90474m

Long 14 Zolushka: Moldarakaja, Ukraine 90200m

Long 15 Hirlatzhohle: Oberosterreich, Austria 84992m

Long 16 Toca da Boa Vista: Bahia, Brazil 84000m

Long 17 Friars Hole Cave System, West Virginia, USA 71052m

Long 18 Sistema Ox Bel Ha: Quintana Roo, Mexico 70650m

Long 19 Easegill System: Yorkshire Dales, UK 70500m

Long 20 Raucherkarhohle, Oberosterreich, Austria 65000m

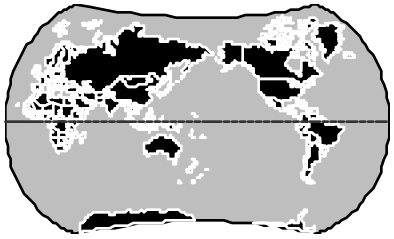
LIMESTONE IN THE WORLD

Objectives:

Students will discover where the longest and deepest caves in the world are located and correlate the presence of limestone with the location of long and deep caves.

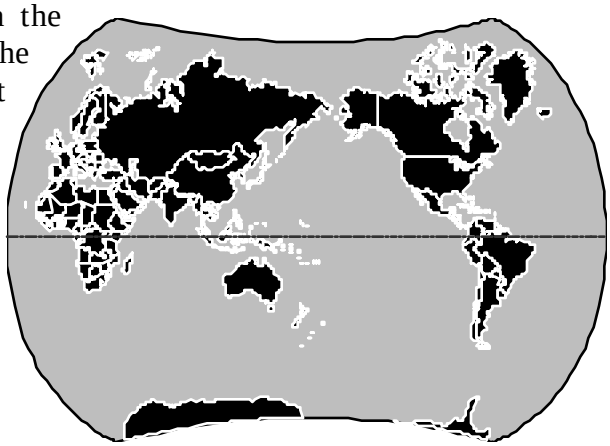
Materials:

- Large, laminated world map
- Names and locations of 50 longest and 50 deepest caves in the world, on small strips of paper
- Hat or bowl
- 2 large dry-erase markers (different colors)
- World atlas and/or geography text



Procedure:

1. Tell the class that they are going to locate the longest and deepest cave in the world. Walk around the room, allowing each student to pick one cave name/location out of the hat or bowl. Repeat until all of the caves have been distributed.
2. Give the students enough time to research the location of their caves, using a geography text or atlas. You may need to help the students with some of the more obscure cave locations.
3. As soon as a student knows the location of one or more of their caves, they may locate it and mark it on the large world map, using a dry-erase marker. Make sure that all caves are marked in one color. The other dry-erase marker is for your use later on!
4. Once all of the caves have been located, ask the students why they think the caves are located where they are. Is there a certain rock type that is best for cave formation? The students may remember from the video that 95% of caves are formed in limestone. With the other marker color, shade the areas of the map where large limestone deposits are found, using the map on page 14 of the enclosed book, *Caves*.
5. Do the students see a connection between the locations of limestone deposits and the locations of caves? Which caves are not located in limestone regions? Why is there no limestone in Hawaii? Discuss lava tubes and other non-limestone caves. Are there any large deposits of limestone in the world that do not contain extensive caves? Why? In some areas, exploration of caves may be difficult for political reasons (such as China).



Topics for discussion

When showing this video to students, discuss the following topics.

- Discuss the processes of the formation of speleothems to make sure it is understood. Emphasize the process of water dripping, flowing, and seeping, while leaving calcite behind through degassing and evaporation. The basic process of the formation of stalactites and stalagmites happens when water traveling from the surface picks up carbon dioxide from the plants and/or soil. This causes the water to become acidic or carbonic acid. This acid has the power to dissolve limestone (calcite is the basis of limestone) and carry it in solution. When the carbonic acid (water) enters an air filled chamber (cave), the carbon dioxide degasses (leaves) from the water (the carbon dioxide goes back into the air). This results in the pH level of the water changing. The water can no longer hold the limestone (calcite) in solution. So it leaves small particles (crystals) of it on the wall of the cave. If the water is dripping it will create a stalactite. If the water doesn't lose the carbon dioxide until it hits the floor of the cave, it will create a stalagmite. Most other speleothems are formed in some variation of this process. For more information about how speleothems form, explore Carol Hill's book *Cave Minerals of the World.*

- Discuss the impact on caves caused by various uses (i.e. mining cave minerals, health care, public tours, etc.). How could these impacts be avoided?

- The draperies seen on the Luray Cave "Organ" were filed down to make the various notes. How might this affect the formations?

- Discuss the section showing the conflict between the above ground crayfish and the blind cave crayfish. While the video showed the advantages the above ground crayfish had in size and vision, would it be able to survive as well as the blind cave crayfish in a cave environment